

In the Claims:

Please amend the claims as follows:

- 1 1. (Cancelled) An apparatus for testing functionality, evaluating performance  
2 and measuring capacitance of a photo-conversion device of at least one  
3 active pixel sensor of an array of active pixel sensors comprising a column  
4 bus, a signal conditioning and readout circuit and a chain of circuitry  
5 connected to said active pixel sensors comprising:  
  
6 a test voltage selection circuit for selectively applying any of a plurality of voltage  
7 levels that vary incrementally from a first voltage level to a second voltage  
8 level to a reference distribution node of the active pixel sensors; and  
  
9 a timing control circuit connected to the test voltage means, to said array  
10 of active pixel sensors, and to a signal conditioning and readout circuit  
11 to provide signals to select timings to select application of the first  
12 voltage level and the second voltage level to the reference distribution  
13 node of said active pixel sensors, signals at appropriate timings to  
14 condition said active pixel sensors in preparation for sensing light  
15 impinging upon said array of active pixel sensors, and providing  
16 signals for timing said signal conditioning and readout circuit to sense  
17 a signal from each active pixel sensor indicating a magnitude of light  
18 impinging upon said array of active pixel sensors.

1     2.     (Cancelled) The apparatus of claim 1 wherein said test voltage selection  
2           circuit comprises:  
  
3           a first switch having a first terminal connected to a first voltage source that  
4           provides said first voltage level, a second terminal connected to the  
5           reference distribution node of at least one active pixel sensor on a row  
6           of active pixel sensors, and a control terminal connected to the  
7           controlling means to selectively connect and disconnect the first  
8           terminal with the second terminal;  
  
9           a second switch having a first terminal connected to a second voltage  
10          source that provides said second voltage level, a second terminal  
11          connected to the reference distribution node of at least one active pixel  
12          sensor on the row of active pixel sensors in the array of active pixel  
13          sensors, and a control terminal connected to the controlling means to  
14          selectively connect and disconnect the first terminal with the second  
15          terminal; and  
  
16          a current measuring device connected so as to measure a current flowing  
17          from said first voltage source.

1     3.     (Cancelled) The apparatus of claim 1 wherein the timing control circuit  
2           enables measurement of the capacitance of the photo-conversion device  
3           within one active pixel sensor by the steps of:

4 at a first time, selecting said active pixel sensor;

5 at a second time, placing the second voltage level at the reference

6 distribution node of said active pixel sensor;

7 simultaneously, at the second time, coupling said second voltage level to

8 the photo-conversion device;

9 at a third time, applying the first voltage level to the reference distribution

10 node;

11 simultaneously, at the third time, coupling said first voltage level to said

12 photo-conversion device;

13 measuring a current flowing to said photo-conversion device to charge the

14 capacitance of the photo-conversion device, whereby said capacitance

15 is determined by the formula:

$$C_{FD} = \frac{I}{dV/dt}$$

17 where

18  $C_{FD}$  is the total capacitance of the photo-

19 conversion devices and the parasitic

20 capacitance of said test voltage select means,

21 I is the current flowing from said first voltage  
22 source,

23  $dv$  is the difference between the first voltage  
24 level and the second voltage level, and

25  $dt$  is a charging time for said capacitance;

1 4. (Cancelled) The apparatus of claim 1 wherein the timing control circuit  
2 enables testing functionality of a row of said active pixel sensors within the  
3 array of active pixel sensors and the chain of circuitry connecting said  
4 selected row of active pixel sensors by the steps of:

5 at a first time, selecting said row of active pixel sensors;

6 at a second time, placing one of the plurality of voltage levels on each  
7 reference distribution node of each active pixel sensor, whereby a  
8 magnitude of said voltage level placed on each reference distribution  
9 node is indicative of a position on said row of active pixel sensors of  
10 each active pixel sensor;

11 simultaneously, at the second time, coupling the voltage level of the  
12 plurality of voltage levels to the photo-conversion device to charge the  
13 capacitance of the photo-conversion device to the voltage level;

14 at a third time, sampling and holding the voltage level of the capacitance  
15 of each active pixel sensor on the selected row of active pixel sensors  
16 within the signal conditioning and readout circuit;

17 at a fourth time, placing the first voltage level at the reference distribution  
18 node of each active pixel sensor on the row of active pixel sensors;

19 simultaneously, at the fourth time, coupling said first voltage level to the  
20 capacitance of the photo-conversion device of each active pixel sensor  
21 of the row of active pixel sensors;

22 at a fifth time, sampling and holding the first voltage level on the  
23 capacitance of the photo-conversion device of each active pixel sensor  
24 on the selected row of active pixel sensors within the signal  
25 conditioning and readout circuit;

26 placing the sampled and held voltage level of the plurality of voltage levels  
27 and the sampled and held first voltage level of each active pixel sensor  
28 of the selected row of active pixel sensors at an output port of the  
29 signal conditioning and readout circuit for transfer to external circuitry,  
30 whereby the external circuitry differentially compares the sampled and  
31 held voltage level of the plurality of voltage levels with the sampled and  
32 held first voltage level and the functionality of each active pixel sensor  
33 on the selected row of active pixel sensors, and the chain of circuitry  
34 connected to each active pixel sensor of the row of active pixel sensors

35 is determined as a function of a difference between the sampled and  
36 held voltage level of the plurality of voltage levels and the sampled and  
37 held first voltage level.

1 5. (Cancelled) The apparatus of claim 1 wherein the timing control circuit  
2 enables evaluating performance of at least one active pixel sensor and the  
3 chain of circuitry connected to said active pixel sensor by the steps of:  
4 at a first time, selecting the active pixel sensor;  
5 at a second time, placing the second voltage level at the reference  
6 distribution node of the active pixel sensor;  
7 simultaneously, at the second time, coupling said second voltage level to  
8 the capacitance of said photo-conversion device;  
9 at a third time, sampling and holding the second voltage level within the  
10 signal conditioning and readout circuit;  
11 at a fourth time, placing the first voltage level at the reference distribution  
12 node of said active pixel sensor;  
13 simultaneously, at the fourth time, coupling said first voltage level to the  
14 capacitance of the photo-conversion device;

15 at a fifth time, sampling and holding the first voltage level from said  
16 capacitance of said photo-conversion device of said active pixel sensor  
17 to the signal conditioning and readout circuit; and  
  
18 placing the sampled and held first voltage level and the sampled and held  
19 second voltage level at an output of the signal conditioning and  
20 readout circuit for transfer to external circuitry, whereby the external  
21 circuitry differentially compares the sampled and held first voltage level  
22 and the sampled and held second voltage level such that the  
23 difference of the sampled and held first voltage level and the sampled  
24 and held second voltage level determines performance of the active  
25 pixel sensor.

1 6. (Cancelled) The apparatus of claim 1 wherein the test voltage selection  
2 circuit comprises:  
  
3 a first voltage distribution line containing a first distribution voltage level;  
  
4 a second voltage distribution line containing a second distribution voltage  
5 level;  
  
6 a first switch having a first terminal connected to a first voltage source that  
7 provides the first voltage level, a second terminal connected to the first  
8 voltage distribution line, a third terminal connected to the second  
9 voltage distribution line, and a control terminal connected to the timing

10           and control means to selectively connect the first terminal to the  
11           second and third terminals concurrently;

12           a second switch having a first terminal connected to a second voltage  
13           source that provides the second voltage level, a second terminal  
14           connected to the first voltage distribution line, a third terminal  
15           connected to the second voltage distribution line, and a control  
16           terminal connected to the timing and control means to selectively  
17           connect the first terminal to the second and third terminals  
18           concurrently;

19           a third switch having a first terminal connected to the first voltage source,  
20           a second terminal connected to the second voltage source, a third  
21           terminal connected to the first voltage distribution line, a fourth terminal  
22           connected to the second voltage distribution line, and a control  
23           terminal connected to the timing and control means to selectively  
24           connect the first terminal to the third terminal and concurrently connect  
25           the second terminal to the fourth terminal;

26           a voltage dividing means connected between the first voltage distribution  
27           line, and connected to the reference distribution node of each active  
28           pixel sensor on a row of active pixel sensors for the array of active  
29           pixel sensors for distributing an incremental voltage level that varies  
30           fractionally from the first distributed voltage level present at the first



31 voltage distribution line to the second distributed voltage level present  
32 at the second voltage distribution line; and  
33 a current measuring means connected so as to measure current flowing  
34 from said first voltage source.

1 7. (Cancelled) The apparatus of claim 5 wherein the timing control circuit  
2 enables measurement of the capacitance of the photo-conversion device  
3 within a group of active pixel sensors of the array of active pixel sensors  
4 by the steps of:  
5 at a first time, selecting said group of active pixel sensors;  
6 during a period of time between a second time and a third time, activating  
7 said second switch to connect the first terminal of the second switch to  
8 connect the second terminal and third terminal of said second switch to  
9 apply the second voltage level to the first and second voltage  
10 distribution lines and thus to the reference distribution node of each  
11 active pixel sensor of the group of active pixel sensors;  
12 simultaneously, during the period between said second time and said third  
13 time, coupling said second voltage level to the capacitance of the  
14 photo-conversion device of each active pixel sensor of the group of  
15 active pixel sensors to charge said capacitance to said second voltage  
16 level;

17 during a period of time between a fourth time and a fifth time, activating  
18 said first switch to connect the first terminal of said first switch  
19 concurrently to the second and third terminals of said first switch to  
20 apply the first voltage level to the first and second voltage distribution  
21 lines and thus to the reference distribution node of each active pixel  
22 sensor of the group of active pixel sensors;

23 simultaneously, during the period between the fourth and fifth time,  
24 coupling said first voltage level to the capacitance of the photo-  
25 conversion device of each active pixel sensor of the group of active  
26 pixel sensors to charge said capacitance of said photo-conversion  
27 device to the first voltage level;

28 measuring a current flowing from said first voltage source to charge the  
29 capacitance of the photo-conversion device of each active pixel sensor  
30 of the group of active pixel sensors, whereby a total capacitance of the  
31 photo-conversion devices of the group of active pixel sensors and a  
32 parasitic capacitance of said test voltage select means is determined  
33 by the formula:

$$C_T = \frac{I_T}{dV/dt_{CT}}$$

35 where

36  $C_T$  is the total capacitance of the photo-  
37 conversion devices and the parasitic  
38 capacitance of said test voltage select means,  
39  $I_T$  is the current flowing from said first voltage  
40 source,  
41  $dV$  is the difference between the first voltage  
42 level and the second voltage level, and  
43  $dt_{CT}$  is a charging time for the total  
44 capacitance;  
45 during a period of time between a sixth time and a seventh time, activating  
46 said second switch to connect the first terminal of the second switch to  
47 connect the second terminal and third terminal of said second switch to  
48 apply the second voltage level to the first and second voltage  
49 distribution lines and thus to the reference distribution node of each  
50 active pixel sensor of the group of active pixel sensors;  
51 during a period of time between an eighth time and a ninth time,  
52 activating said first switch to connect the first terminal of said  
53 first switch concurrently to the second and third terminals of said  
54 first switch to apply the first voltage level to the first and second  
55 voltage distribution lines and thus to the reference distribution

56 node of each active pixel sensor of the group of active pixel  
57 sensors;

58 measuring a current flowing from said first voltage source to charge the  
59 parasitic capacitance of said test voltage select means is determined  
60 by the formula:

61 
$$C_P = \frac{I_P}{dV/dt_{CP}}$$

62 where

63  $C_P$  is the parasitic capacitance of said  
64 test voltage select means,

65  $I_P$  is the current flowing to the parasitic  
66 capacitance  $C_P$  during charging  
67 from the second voltage level to  
68 the first voltage level,

69  $dV$  is a difference between the first voltage  
70 level and the second voltage level, and

71  $dt_{CP}$  is a charging time for the parasitic  
72 capacitance,

such that an average capacitance of the photo-conversion device of  
each of said active pixel sensors of said group of active pixel  
sensors is determined by the formula:

$$\overline{C_{FD}} = \frac{C_T - C_P}{n}$$

where

$\overline{C_{FD}}$  is the average capacitance of the  
photodiode,

$C_T$  is the total capacitance,

$C_P$  is the parasitic capacitance, and

$n$  is a number of active pixel sensors of the  
group of active pixel sensors.

8. (Cancelled) The apparatus of claim 6 wherein the timing control circuit  
enables testing functionality of a group of at least one active pixel sensor  
by the steps of:
- at a first time, selecting said group of active pixel sensors;
- during a period of time between a second time and a third time, activating  
said third switch to apply said first voltage level to said first voltage

7 distribution line and to apply said second voltage level to said second  
8 voltage distribution line such that one of the incremental voltage levels  
9 is applied to the reference distribution node of each active pixel sensor  
10 of the group of active pixel sensors;

11 simultaneously, during the period between the second and third time,  
12 coupling said incremental voltage level to the capacitance of the photo-  
13 conversion device of each active pixel sensor to the row of active pixel  
14 sensors to charge said capacitance of the photo-conversion device to  
15 the incremental voltage level;

16 during a period of time between a fourth time and a fifth time, sampling  
17 and holding within the signal conditioning and readout circuit the  
18 incremental voltage level present on the capacitance of the photo-  
19 conversion device of each of the active pixel sensors of the group of  
20 active pixel sensors;

21 during a period of time between a sixth time and a seventh time, activating  
22 said first switch to apply the first voltage level to the first voltage  
23 distribution line and the second voltage distribution line to place the  
24 first voltage level at the reference distribution node of each active pixel  
25 sensor of the group of active pixel sensors;

26 simultaneously, during the period of time between the sixth time and the  
27 seventh time, coupling said first voltage level from the reference

28           distribution node to the capacitance of the photo-conversion device of  
29           each active pixel sensor of the group of active pixel sensors to charge  
30           said capacitance of the photo-conversion device from said incremental  
31           voltage level to said first voltage level;

32           during a period of time between an eighth time and a ninth time, sampling  
33           and holding within the signal conditioning and readout circuit said first  
34           voltage level present on said capacitance of said photo-conversion  
35           device of each active pixel sensor of the group of active pixel sensors;

36           placing the sampled and held incremental voltage level present of the  
37           capacitance of the photo-conversion device of each of the active pixel  
38           sensors of the group of active pixel sensors and the sampled and held  
39           first voltage level of each of the active pixel sensors of the group of  
40           active pixel sensors at an output port of the signal conditioning and  
41           readout circuit for transfer to external circuitry, whereby the external  
42           circuitry differentially compares said sampled and held incremental  
43           voltage level and said first voltage level, thus determining the  
44           functionality of each active pixel sensor of the group of active pixel  
45           sensors, and the chain of circuitry connected to each active pixel  
46           sensor of the group of active pixel sensors is determined as a function  
47           of a difference between the sampled and held incremental voltage  
48           level and the sampled and held first voltage level.

1 9. (Cancelled) The apparatus of claim 6 wherein the timing control circuit  
2 enables evaluating performance of a group of at least one active pixel  
3 sensor of the array of active pixel sensors by the steps of:  
4 at a first time, selecting said group of active pixel sensors;  
5 during a period of time between a second time and a third time, activating  
6 said second switch to apply said second voltage level to said voltage  
7 distribution line such that said second voltage level is applied to the  
8 reference distribution node of each active pixel sensor of the group of  
9 active pixel sensors;  
10 simultaneously, during the period of time between the second and third  
11 time, coupling said second voltage level to the capacitance of the  
12 photo-conversion device of each active pixel sensor to the row of  
13 active pixel sensors to charge said capacitance of the photo-  
14 conversion device to the second voltage level;  
15 during a period of time between a fourth time and a fifth time, sampling  
16 and holding within the signal conditioning and readout circuit the  
17 second voltage level present on the capacitance of the photo-  
18 conversion device of each of the active pixel sensors of the group of  
19 active pixel sensors;



20 during a period of time between a sixth time and a seventh time, activating  
21 said first switch to apply the first voltage level to the first voltage  
22 distribution line and the second voltage distribution line to place the  
23 first voltage level at the reference distribution node of each active pixel  
24 sensor of the group of active pixel sensors;

25 simultaneously, during the period of time between the sixth time and the  
26 seventh time, coupling said first voltage level from the reference  
27 distribution node to the capacitance of the photo-conversion device of  
28 each active pixel sensor of the group of active pixel sensors to charge  
29 said capacitance of the photo-conversion device from said incremental  
30 voltage level to said first voltage level;

31 during a period of time between an eighth time and a ninth time, sampling  
32 and holding within the signal conditioning and readout circuit said first  
33 voltage level present on said capacitance of each active pixel sensor of  
34 the group of active pixel sensors;

35 placing the sampled and held second voltage level present on the  
36 capacitance of the photo-conversion device of each of the active pixel  
37 sensors of the group of active pixel sensors and the sampled and held  
38 first voltage level of each of the active pixel sensors of the group of  
39 active pixel sensors at an output port of the signal conditioning and  
40 readout circuit for transfer to external circuitry, whereby the external

41           circuitry differentially compares said sampled and held second voltage  
42           level and said first voltage level, thus determining performance of each  
43           active pixel sensor of the group of active pixel sensors and of the chain  
44           of circuitry connected to each active pixel sensor of the group of active  
45           pixel sensors is determined as a function of a difference between the  
46           sampled and held incremental voltage level and the sampled and held  
47           first voltage level.

1    10.   (Cancelled) The apparatus of claim 9 wherein evaluating performance of  
2           each active pixel sensor of the group of active pixel sensors includes  
3           evaluating range and linearity of each active pixel sensor and the chain of  
4           circuitry connected to active pixel sensor.

1    11.   (Cancelled) The apparatus of claim 6 wherein the group of active pixel  
2           sensors is a row of active pixel sensors placed in an area of dark pixels of  
3           the array of active pixel sensors.

1    12.   (Cancelled) A photo-imaging integrated circuit comprising:  
2           containing said an array of active pixel sensors arranged in rows and  
3           columns whereby each active pixel sensor comprises:  
4           a photo-conversion device which converts light impinging upon said  
5           photo-conversion device to electrons which are retained at a  
6           capacitance of said photo-conversion device,

7                   a reset reference means connected to said photo-conversion  
8                   d vice to selectively apply a reference voltage level to said  
9                   photo-conversion device,  
10                  a reference distribution node connected to the reset reference  
11                  means reference voltage level,  
12                  a source follower means connected to the photo-conversion device  
13                  to provide an output voltage level at an output terminal  
14                  approximating a voltage present on said photo-conversion  
15                  device, and  
16                  a pixel selecting means connected to the source follower means to  
17                  activate said source follower means to transfer the output  
18                  voltage level to said output terminal;  
19                  a test voltage selection means connected to at least one active pixel for  
20                  selectively applying any of a plurality of voltage levels that vary  
21                  incrementally from a first voltage level to a second voltage level to the  
22                  reference distribution node of the active pixel sensors;  
23                  a plurality of column bus means connected such that each column bus  
24                  means is connected to each output terminal of each active pixel sensor  
25                  of each column of active pixel sensors;

26 a plurality of signal conditioning and readout circuits, whereby each signal  
27 conditioning and readout circuit is connected to each column bus  
28 means to sample and hold the output voltage level at the output  
29 terminal of a selected active pixel sensors of a row of active pixel  
30 sensors, and in response to said output signal provide a first and  
31 second sampled and held output signal; and

32 a timing and control means connected to the array of active pixel sensors,  
33 the test voltage selection means and the plurality of signal conditioning  
34 and readout circuits to provide timing and control signals that select  
35 active pixel sensors to transfer signals to the column bus and thence to  
36 the signal conditioning and readout circuits, and to provide the first and  
37 second sampled and held readout signals.

1 13. (Cancelled) The photo-imaging integrated circuit of claim 12 wherein said  
2 test voltage selection means comprises:

3 a first switch having a first terminal connected to a first voltage source that  
4 provides said first voltage level, a second terminal connected to the  
5 reference distribution node of at least one active pixel sensor on a row  
6 of active pixel sensors, and a control terminal connected to the  
7 controlling means to selectively connect and disconnect the first  
8 terminal with the second terminal;

9 a second switch having a first terminal connected to a second voltage  
10 source that provides said second voltage level, a second terminal  
11 connected to the reference distribution node of at least one active pixel  
12 sensor on the row of active pixel sensors in the array of active pixel  
13 sensors, and a control terminal connected to the controlling means to  
14 selectively connect and disconnect the first terminal with the second  
15 terminal; and

16 a current measuring device connected so as to measure a current flowing  
17 from said first voltage source.

18 14. (Cancelled) The photo-imaging integrated circuit of claim 12 wherein the  
19 timing control means enables measurement of the capacitance of the  
20 photo-conversion device within one active pixel sensor by the steps of:

21 at a first time, selecting said active pixel sensor;

22 at a second time, placing the second voltage level at the reference  
23 distribution node of said active pixel sensor;

24 simultaneously, at the second time, coupling said second voltage level to  
25 the photo-conversion device;

26 at a third time, applying the first voltage level to the reference distribution  
27 node ;

simultaneously, at the third time, coupling said first voltage level to said  
photo-conversion device;

measuring a current flowing to said photo-conversion device to charge the  
capacitance of the photo-conversion device, whereby said capacitance  
is determined by the formula:

$$C_{FD} = \frac{I}{dV/dt}$$

where

$C_{FD}$  is the total capacitance of the photo-  
conversion devices and the parasitic  
capacitance of said test voltage select means,

$I$  is the current flowing from said first voltage  
source,

$dV$  is the difference between the first voltage  
level and the second voltage level, and

$dt$  is a charging time for said capacitance;

15. (Cancelled) The photo-imaging integrated circuit of claim 12 wherein the  
timing control means enables testing functionality of a row of said active  
pixel sensors within the array of active pixel sensors and the chain of

4       circuitry connecting said selected row of active pixel sensors by the steps  
5       of:

6       at a first time, selecting said row of active pixel sensors;

7       at a second time, placing one of the plurality of voltage levels on each  
8       reference distribution node of each active pixel sensor, whereby a  
9       magnitude of said voltage level placed on each reference distribution  
10      node is indicative of a position on said row of active pixel sensors of  
11      each active pixel sensor;

12      simultaneously, at the second time, coupling the voltage level of the  
13      plurality of voltage levels to the photo-conversion device to charge the  
14      capacitance of the photo-conversion device to the voltage level;

15      at a third time, sampling and holding the voltage level of the capacitance  
16      of each active pixel sensor on the selected row of active pixel sensors  
17      within the signal conditioning and readout circuit;

18      at a fourth time, placing the first voltage level at the reference distribution  
19      node of each active pixel sensor on the row of active pixel sensors;

20      simultaneously, at the fourth time, coupling said first voltage level to the  
21      capacitance of the photo-conversion device of each active pixel sensor  
22      of the row of active pixel sensors;

23 at a fifth time, sampling and holding the first voltage level on the  
24 capacitance of the photo-conversion device of each active pixel sensor  
25 on the selected row of active pixel sensors within the signal  
26 conditioning and readout circuit;

27 placing the sampled and held voltage level of the plurality of voltage levels  
28 and the sampled and held first voltage level of each active pixel sensor  
29 of the selected row of active pixel sensors at an output port of the  
30 signal conditioning and readout circuit for transfer to external circuitry,  
31 whereby the external circuitry differentially compares the sampled and  
32 held voltage level of the plurality of voltage levels with the sampled and  
33 held first voltage level and the functionality of each active pixel sensor  
34 on the selected row of active pixel sensors, and the chain of circuitry  
35 connected to each active pixel sensor of the row of active pixel sensors  
36 is determined as a function of a difference between the sampled and  
37 held voltage level of the plurality of voltage levels and the sampled and  
38 held first voltage level.

1 16. (Cancelled) The photo-imaging integrated circuit of claim 12 wherein the  
2 timing and control means enables evaluating performance of at least one  
3 active pixel sensor and the chain of circuitry connected to said active pixel  
4 sensor by the steps of:

5 at a first time, selecting the active pixel sensor;



6 at a second time, placing the second voltage level at the reference  
7 distribution node of the active pixel sensor;

8 simultaneously, at the second time, coupling said second voltage level to  
9 the capacitance of said photo-conversion device;

10 at a third time, sampling and holding the second voltage level within the  
11 signal conditioning and readout circuit;

12 at a fourth time, placing the first voltage level at the reference distribution  
13 node of said active pixel sensor;

14 simultaneously, at the fourth time, coupling said first voltage level to the  
15 capacitance of the photo-conversion device;

16 at a fifth time, sampling and holding the first voltage level from said  
17 capacitance of said photo-conversion device of said active pixel sensor  
18 to the signal conditioning and readout circuit; and

19 placing the sampled and held first voltage level and the sampled and held  
20 second voltage level at an output of the signal conditioning and  
21 readout circuit for transfer to external circuitry, whereby the external  
22 circuitry differentially compares the sampled and held first voltage level  
23 and the sampled and held second voltage level such that the  
24 difference of the sampled and held first voltage level and the sampled

25           and held second voltage level determines performance of the active  
26           pixel sensor.

1    17.   (Cancelled) The photo-imaging integrated circuit of claim 12 wherein the  
2           test voltage selection means comprises:

3           a first voltage distribution line containing a first distribution voltage level;

4           a second voltage distribution line containing a second distribution voltage  
5           level;

6           a first switch having a first terminal connected to a first voltage source that  
7           provides the first voltage level, a second terminal connected to the first  
8           voltage distribution line, a third terminal connected to the second  
9           voltage distribution line, and a control terminal connected to the timing  
10          and control means to selectively connect the first terminal to the  
11          second and third terminals concurrently;

12          a second switch having a first terminal connected to a second voltage  
13          source that provides the second voltage level, a second terminal  
14          connected to the first voltage distribution line, a third terminal  
15          connected to the second voltage distribution line, and a control  
16          terminal connected to the timing and control means to selectively  
17          connect the first terminal to the second and third terminals  
18          concurrently;

19 a third switch having a first terminal connected to the first voltage source,  
20 a second terminal connected to the second voltage source, a third  
21 terminal connected to the first voltage distribution line, a fourth terminal  
22 connected to the second voltage distribution line, and a control  
23 terminal connected to the timing and control means to selectively  
24 connect the first terminal to the third terminal and concurrently connect  
25 the second terminal to the fourth terminal;

26 a voltage dividing means connected between the first voltage distribution  
27 line, and connected to the reference distribution node of each active  
28 pixel sensor on a row of active pixel sensors for the array of active  
29 pixel sensors for distributing an incremental voltage level that varies  
30 fractionally from the first distributed voltage level present at the first  
31 voltage distribution line to the second distributed voltage level present  
32 at the second voltage distribution line; and

33 a current measuring means connected so as to measure current flowing  
34 from said first voltage source.

1 18. (Cancelled) The photo-imaging integrated circuit of claim 17 wherein the  
2 timing and control means enables measurement of the capacitance of the  
3 photo-conversion device within a group of active pixel sensors of the array  
4 of active pixel sensors by the steps of:

5 at a first time, selecting said group of active pixel sensors;

6           during a period of time between a second time and a third time, activating  
7           said second switch to connect the first terminal of the second switch to  
8           connect the second terminal and third terminal of said second switch to  
9           apply the second voltage level to the first and second voltage  
10          distribution lines and thus to the reference distribution node of each  
11          active pixel sensor of the group of active pixel sensors;

12          simultaneously, during the period between said second time and said third  
13          time, coupling said second voltage level to the capacitance of the  
14          photo-conversion device of each active pixel sensor of the group of  
15          active pixel sensors to charge said capacitance to said second voltage  
16          level;

17          during a period of time between a fourth time and a fifth time, activating  
18          said first switch to connect the first terminal of said first switch  
19          concurrently to the second and third terminals of said first switch to  
20          apply the first voltage level to the first and second voltage distribution  
21          lines and thus to the reference distribution node of each active pixel  
22          sensor of the group of active pixel sensors;

23          simultaneously, during the period between the fourth and fifth time,  
24          coupling said first voltage level to the capacitance of the photo-  
25          conversion device of each active pixel sensor of the group of active

26 pixel sensors to charge said capacitance of said photo-conversion  
27 device to the first voltage level;  
  
28 measuring a current flowing from said first voltage source to charge the  
29 capacitance of the photo-conversion device of each active pixel sensor  
30 of the group of active pixel sensors, whereby a total capacitance of the  
31 photo-conversion devices of the group of active pixel sensors and a  
32 parasitic capacitance of said test voltage select means is determined  
33 by the formula:

34 
$$C_T = \frac{I_T}{dV/dt_{CT}}$$

35 where

36  $C_T$  is the total capacitance of the photo-  
37 conversion devices and the parasitic  
38 capacitance of said test voltage select means,

39  $I_T$  is the current flowing from said first voltage  
40 source,

41  $dV$  is the difference between the first voltage  
42 level and the second voltage level, and

43  $dt_{CT}$  is a charging time for the total  
44 capacitance;

45 during a period of time between a sixth time and a seventh time, activating  
46 said second switch to connect the first terminal of the second switch to  
47 connect the second terminal and third terminal of said second switch to  
48 apply the second voltage level to the first and second voltage  
49 distribution lines and thus to the reference distribution node of each  
50 active pixel sensor of the group of active pixel sensors;

51 during a period of time between an eighth time and a ninth time, activating  
52 said first switch to connect the first terminal of said first switch  
53 concurrently to the second and third terminals of said first switch to  
54 apply the first voltage level to the first and second voltage distribution  
55 lines and thus to the reference distribution node of each active pixel  
56 sensor of the group of active pixel sensors;

57 measuring a current flowing from said first voltage source to charge the  
58 parasitic capacitance of said test voltage select means is determined  
59 by the formula:

60 
$$C_P = \frac{I_P}{dV / dt_{CP}}$$

61 where

$C_P$  is the parasitic capacitance of said  
test voltage select means,

$I_P$  is the current flowing to the parasitic  
capacitance  $C_P$  during charging  
from the second voltage level to  
the first voltage level,

$dv$  is a difference between the first voltage  
level and the second voltage level, and

$dt_{CP}$  is a charging time for the parasitic  
capacitance,

such that an average capacitance of the photo-conversion device of  
each of said active pixel sensors of said group of active pixel  
sensors is determined by the formula:

$$\overline{C_{FD}} = \frac{C_T - C_P}{n}$$

where

$\overline{C_{FD}}$  is the average capacitance of the  
photodiode,

$C_T$  is the total capacitance,

80  $C_p$  is the parasitic capacitance, and  
81  $n$  is a number of active pixel sensors of the  
82 group of active pixel sensors.

1 19. (Cancelled) The photo-imaging integrated circuit of claim 17 wherein the  
2 timing and control means enables testing functionality of a group of at  
3 least one active pixel sensor by the steps of:  
4 at a first time, selecting said group of active pixel sensors;  
5 during a period of time between a second time and a third time, activating  
6 said third switch to apply said first voltage level to said first voltage  
7 distribution line and to apply said second voltage level to said second  
8 voltage distribution line such that one of the incremental voltage levels  
9 is applied to the reference distribution node of each active pixel sensor  
10 of the group of active pixel sensors;  
11 simultaneously, during the period between the second and third time,  
12 coupling said incremental voltage level to the capacitance of the photo-  
13 conversion device of each active pixel sensor to the row of active pixel  
14 sensors to charge said capacitance of the photo-conversion device to  
15 the incremental voltage level;  
16 during a period of time between a fourth time and a fifth time, sampling  
17 and holding within the signal conditioning and readout circuit the



18 incremental voltage level present on the capacitance of the photo-  
19 conversion device of each of the active pixel sensors of the group of  
20 active pixel sensors;

21 during a period of time between a sixth time and a seventh time, activating  
22 said first switch to apply the first voltage level to the first voltage  
23 distribution line and the second voltage distribution line to place the  
24 first voltage level at the reference distribution node of each active pixel  
25 sensor of the group of active pixel sensors;

26 simultaneously, during the period of time between the sixth time and the  
27 seventh time, coupling said first voltage level from the reference  
28 distribution node to the capacitance of the photo-conversion device of  
29 each active pixel sensor of the group of active pixel sensors to charge  
30 said capacitance of the photo-conversion device from said incremental  
31 voltage level to said first voltage level;

32 during a period of time between an eighth time and a ninth time, sampling  
33 and holding within the signal conditioning and readout circuit said first  
34 voltage level present on said capacitance of said photo-conversion  
35 device of each active pixel sensor of the group of active pixel sensors;

36 placing the sampled and held incremental voltage level present of the  
37 capacitance of the photo-conversion device of each of the active pixel  
38 sensors of the group of active pixel sensors and the sampled and held

39 first voltage level of each of the active pixel sensors of the group of  
40 active pixel sensors at an output port of the signal conditioning and  
41 readout circuit for transfer to external circuitry, whereby the external  
42 circuitry differentially compares said sampled and held increment  
43 voltage level and said first voltage level, thus determining the  
44 functionality of each active pixel sensor of the group of active pixel  
45 sensors, and the chain of circuitry connected to each active pixel  
46 sensor of the group of active pixel sensors is determined as a function  
47 of a difference between the sampled and held incremental voltage  
48 level and the sampled and held first voltage level.

1 20. (Cancelled) The photo-imaging integrated circuit of claim 17 wherein the  
2 timing and control means enables evaluating performance of a group of at  
3 least one active pixel sensor of the array of active pixel sensors by the  
4 steps of:

5 at a first time, selecting said group of active pixel sensors;  
6 during a period of time between a second time and a third time, activating  
7 said second switch to apply said second voltage level to said voltage  
8 distribution line such that said second voltage level is applied to the  
9 reference distribution node of each active pixel sensor of the group of  
10 active pixel sensors;

11 simultaneously, during the period of time between the second and third  
12 time, coupling said second voltage level to the capacitance of the  
13 photo-conversion device of each active pixel sensor to the row of  
14 active pixel sensors to charge said capacitance of the photo-  
15 conversion device to the second voltage level;

16 during a period of time between a fourth time and a fifth time, sampling  
17 and holding within the signal conditioning and readout circuit the  
18 second voltage level present on the capacitance of the photo-  
19 conversion device of each of the active pixel sensors of the group of  
20 active pixel sensors;

21 during a period of time between a sixth time and a seventh time, activating  
22 said first switch to apply the first voltage level to the first voltage  
23 distribution line and the second voltage distribution line to place the  
24 first voltage level at the reference distribution node of each active pixel  
25 sensor of the group of active pixel sensors;

26 simultaneously, during the period of time between the sixth time and the  
27 seventh time, coupling said first voltage level from the reference  
28 distribution node to the capacitance of the photo-conversion device of  
29 each active pixel sensor of the group of active pixel sensors to charge  
30 said capacitance of the photo-conversion device from said incremental  
31 voltage level to said first voltage level;

32 during a period of time between an eighth time and a ninth time, sampling  
33 and holding within the signal conditioning and readout circuit said first  
34 voltage level present on said capacitance of each active pixel sensor of  
35 the group of active pixel sensors;

36 placing the sampled and held second voltage level present on the  
37 capacitance of the photo-conversion device of each of the active pixel  
38 sensors of the group of active pixel sensors and the sampled and held  
39 first voltage level of each of the active pixel sensors of the group of  
40 active pixel sensors at an output port of the signal conditioning and  
41 readout circuit for transfer to external circuitry, whereby the external  
42 circuitry differentially compares said sampled and held second voltage  
43 level and said first voltage level, thus determining performance of each  
44 active pixel sensor of the group of active pixel sensors and of the chain  
45 of circuitry connected to each active pixel sensor of the group of active  
46 pixel sensors is determined as a function of a difference between the  
47 sampled and held incremental voltage level and the sampled and held  
48 first voltage level.

1 21. (Cancelled) The photo-imaging integrated circuit of claim 20 wherein  
2 evaluating performance of each active pixel sensor of the group of active  
3 pixel sensors includes evaluating range and linearity of each active pixel  
4 sensor and the chain of circuitry connected to active pixel sensor.

- 1 22. (Cancelled) The photo-imaging integrated circuit of claim 20 wherein the  
2 group of active pixel sensors is a row of active pixel sensors placed in an  
3 area of dark pixels of the array of active pixel sensors.
- 1 23. (Original) A method for verifying operation of a group of at least one active  
2 pixel sensor within an array of active pixel sensors and of a chain of  
3 circuitry connected to each active pixel sensor for capturing an output  
4 signal from said active pixel sensor, whereby said chain of circuitry  
5 includes a column bus circuit and a signal conditioning and readout circuit,  
6 and whereby said method comprises the step of:
- 7 testing functionality of said group of active pixel sensors and the chain of  
8 circuitry connected to each active pixel sensor of the group of active  
9 pixel sensors by the steps of:
- 10 activating said group of active pixel sensors,
- 11 applying one of a group of voltage levels that vary incrementally  
12 from a first voltage level to charge a capacitance of a photo-  
13 conversion device of each active pixel sensor of the group of  
14 active pixel sensors to a first charging voltage level and  
15 sampling and holding said first charging voltage level from the  
16 capacitance of the photo-conversion device of each active pixel  
17 sensor of the group of active pixel sensors,

18           applying the first voltage level to charge the capacitance of the  
19           photo-conversion device of each active pixel sensor of the  
20           group of active pixel sensors to a second charging voltage level,  
21           sampling and holding a second charging voltage level from said  
22           capacitance of the photo-conversion device of each active pixel  
23           sensor of the group of active pixel sensors,  
24           differentially comparing the first charging voltage level with the  
25           second charging voltage level to create a first difference  
26           voltage, whereby said first difference voltage indicates the  
27           functionality of each active pixel sensor of the group of active  
28           pixel sensors and the chain of circuitry connected to said active  
29           pixel sensor.

- 1   24.   (Cancelled) A method for verifying operation of a group of at least one  
2           active pixel sensor within an array of active pixel sensors and of a chain of  
3           circuitry connected to each active pixel sensor for capturing an output  
4           signal from said active pixel sensor, whereby said chain of circuitry  
5           includes a column bus circuit and a signal conditioning and readout circuit,  
6           and whereby said method comprises the step of:  
7           evaluating performance of said group of active pixel sensors and the chain  
8           of circuitry connected to each active pixel sensor of the group of active  
9           pixel sensors by the steps of:

10                   activating said group of active pixel sensors ,

11                   applying the second voltage level to charge a capacitance of a

12                   photo-conversion device of each active pixel sensor of the

13                   group of active pixel sensors to a third charging voltage level,

14                   sampling and holding the third charging voltage level from said

15                   capacitance of the photo-conversion device of each active pixel

16                   sensor of the group of active pixel sensors,

17                   applying the first voltage level to charge the capacitance of the

18                   photo-conversion device of each active pixel sensor of the

19                   group of active pixel sensors to a fourth charging voltage level,

20                   sampling and holding the fourth charging voltage level from said

21                   capacitance of the photo-conversion device of each active pixel

22                   sensor of the group of active pixel sensors,

23                   differentially comparing the third charging voltage level with the

24                   fourth charging voltage level to create a second difference

25                   voltage, whereby said second difference voltage indicates said

26                   performance of each active pixel sensor of the group of active

27                   pixel sensors and the chain of circuitry connected to said active

28                   pixel sensor.

1    25.    (Cancelled) A method for verifying operation of a group of at least one  
2           active pixel sensor within an array of active pixel sensors and of a chain of  
3           circuitry connected to each active pixel sensor for capturing an output  
4           signal from said active pixel sensor, whereby said method comprises the  
5           step of:

6           determining an average capacitance of a photo-conversion device of each  
7           active pixel sensor of said group of active pixel sensors by the steps of:

8                applying a first voltage level to charge to a first voltage charging  
9                level a total capacitance including said capacitance of said  
10               photo-conversion device and a parasitic capacitance formed by  
11               interconnecting circuits between a voltage source and providing  
12               said first voltage level and said active pixel sensor,

13               applying a second voltage level provided by a second voltage  
14               source to charge from the first charging voltage level to a  
15               second charging voltage level said total capacitance,

16               measuring a current flowing into said total capacitance,

17               determining a first charging time for the first charging voltage level  
18               to charge to the second charging voltage level,

19               calculating the total capacitance by the formula:



20 
$$C_T = \frac{I_T}{dV/dt_{CT}}$$

21 where

22  $C_T$  is the total capacitance of the photo-  
23 conversion devices and the parasitic  
24 capacitance of said test voltage select means,

25  $I_T$  is the current flowing from said first voltage  
26 source,

27  $dV$  is the difference between the first voltage  
28 level and the second voltage level, and

29  $dt_{CT}$  is a charging time for the total  
30 capacitance;

31 applying the first voltage level to the parasitic capacitance to charge  
32 said parasitic capacitance to a third charging voltage level,

33 applying the second voltage level to the parasitic capacitance to  
34 charge said parasitic capacitance from the third charging  
35 voltage level to a fourth charging voltage level,

36 measuring a current flowing into said parasitic capacitance,

37 determining a second charging time for the third charging  
38 voltage level to charge to the fourth charging voltage  
39 level,

40 calculating the parasitic capacitance by the formula:

41 
$$C_P = \frac{I_P}{dV/dt_{CP}}$$

42 where

43  $C_P$  is the parasitic capacitance of said  
44 test voltage select means,

45  $I_P$  is the current flowing to the parasitic  
46 capacitance  $C_P$  during charging  
47 from the second voltage level to  
48 the first voltage level,

49  $dV$  is a difference between the first voltage  
50 level and the second voltage level, and

51  $dt_{CP}$  is a charging time for the parasitic  
52 capacitance,

53 determining the average capacitance of the photo-conversion  
54 device by the formula:

55 
$$\overline{C_{FD}} = \frac{C_T - C_P}{n}$$

56 where

57  $\overline{C_{FD}}$  is the average capacitance of the  
58 photodiode,

59  $C_T$  is the total capacitance,

60  $C_P$  is the parasitic capacitance, and

61  $n$  is a number of active pixel sensors of the  
62 group of active pixel sensors.

1 26. (Cancelled) A method for verifying operation of a group of at least one  
2 active pixel sensor within an array of active pixel sensors and of a chain of  
3 circuitry connected to each active pixel sensor for capturing an output  
4 signal from said active pixel sensor, whereby said chain of circuitry  
5 includes a column bus circuit and a signal conditioning and readout circuit,  
6 and whereby said method comprises the steps of:

7 testing functionality of said group of active pixel sensors and the chain of  
8 circuitry connected to each active pixel sensor of the group of active  
9 pixel sensors by comparing the difference between two voltage levels  
10 applied to charge a capacitance of a photo-conversion device of each

11 active pixel sensor to a first charging voltage level and a sampled and  
12 held first charging voltage level, whereby an amplitude of said sampled  
13 and held first charging voltage level determines the functionality of said  
14 active pixel sensors and said chain of circuitry;

15 evaluating performance of said groups of active pixel sensors and the  
16 chain of circuitry connected to each active pixel sensor of the group of  
17 active pixel sensors by comparing the difference between a first  
18 voltage level and a second voltage level applied at separate times to  
19 charge the capacitance of the photo-conversion device of each active  
20 pixel sensor to a second charging voltage level and a sampled and  
21 held second charging voltage level, whereby an amplitude of said  
22 sampled and held charging voltage level determines performance of  
23 said group of active pixel sensors; and

24 determining an average capacitance of each photo-conversion device of  
25 each active pixel sensor of the group of active pixel sensors by  
26 charging the capacitance between the first and the second voltage  
27 levels, measuring a charging current into said capacitance, measuring  
28 a charging time, and calculating said capacitance.

1 27. (Cancelled) The method of claim 26 wherein testing functionality  
2 comprises the steps of:

3 activating said group of active pixel sensors;

4       applying one of a group of voltage levels that vary incrementally from a  
5       first voltage  $V_1$  to charge a capacitance of a photo-conversion device  
6       of each active pixel sensor of the group of active pixel sensors to a first  
7       charging voltage level and sampling and holding said first charging  
8       voltage level from the capacitance of the photo-conversion device of  
9       each active pixel sensor of the group of active pixel sensors;

10       applying the first voltage level to charge the capacitance of the photo-  
11       conversion device of each active pixel sensor of the group of active  
12       pixel sensors to a second charging voltage level;

13       sampling and holding a second charging voltage level from said  
14       capacitance of the photo-conversion device of each active pixel sensor  
15       of the group of active pixel sensors;

16       differentially comparing the first charging voltage level with the second  
17       charging voltage level to create a first difference voltage, whereby said  
18       first difference voltage indicates the functionality of each active pixel  
19       sensor of the group of active pixel sensors and the chain of circuitry  
20       connected to said active pixel sensor.

1    28.   (Cancelled) The method of claim 26 wherein evaluating performance  
2       comprises the steps of:

3       activating said group of active pixel sensors ,

4           applying the second voltage level to charge a capacitance of a  
5           photo-conversion device of each active pixel sensor of the  
6           group of active pixel sensors to a third charging voltage level,  
7           sampling and holding the third charging voltage level from said  
8           capacitance of the photo-conversion device of each active pixel  
9           sensor of the group of active pixel sensors,  
10          applying the first voltage level to charge the capacitance of the  
11          photo-conversion device of each active pixel sensor of the  
12          group of active pixel sensors to a fourth charging voltage level,  
13          sampling and holding the fourth charging voltage level from said  
14          capacitance of the photo-conversion device of each active pixel  
15          sensor of the group of active pixel sensors,  
16          differentially comparing the third charging voltage level with the  
17          fourth charging voltage level to create a second difference  
18          voltage, whereby said second difference voltage indicates said  
19          performance of each active pixel sensor of the group of active  
20          pixel sensors and the chain of circuitry connected to said active  
21          pixel sensor.

1   29.   (Cancelled) The method of claim 26 wherein determining average  
2          capacitance comprises the steps of:

3           applying a first voltage level to charge to a first voltage charging  
4           level a total capacitance including said capacitance of said  
5           photo-conversion device and a parasitic capacitance formed by  
6           interconnecting circuits between a voltage source and providing  
7           said first voltage level and said active pixel sensor,  
8           applying a second voltage level provided by a second voltage  
9           source to charge from the first charging voltage level to a  
10          second charging voltage level said total capacitance,  
11          measuring a current flowing into said total capacitance,  
12          determining a first charging time for the first charging voltage level  
13          to charge to the second charging voltage level,  
14          calculating the total capacitance by the formula:

$$C_T = \frac{I_T}{dV/dt_{CT}}$$

16           where

17            $C_T$  is the total capacitance of the photo-  
18           conversion devices and the parasitic  
19           capacitance of said test voltage select means,

20  $I_T$  is the current flowing from said first voltage  
21 source,

22  $dV$  is the difference between the first voltage  
23 level and the second voltage level, and

24  $dt_{CT}$  is a charging time for the total  
25 capacitance;

26

27 applying the first voltage level to the parasitic capacitance to charge  
28 said parasitic capacitance to a third charging voltage level,

29 applying the second voltage level to the parasitic capacitance to  
30 charge said parasitic capacitance from the third charging  
31 voltage level to a fourth charging voltage level,

32 measuring a current flowing into said parasitic capacitance,

33 determining a second charging time for the third charging  
34 voltage level to charge to the fourth charging voltage  
35 level,

36 calculating the parasitic capacitance by the formula:



37 
$$C_P = \frac{I_P}{dV/dt_{CP}}$$

38 where

39  $C_P$  is the parasitic capacitance of said  
40 test voltage select means,

41  $I_P$  is the current flowing to the parasitic  
42 capacitance  $C_P$  during charging  
43 from the second voltage level to  
44 the first voltage level,

45  $dV$  is a difference between the first voltage  
46 level and the second voltage level, and

47  $dt_{CP}$  is a charging time for the parasitic  
48 capacitance,

49

50 determining the average capacitance of the photo-conversion  
51 device by the formula:

52 
$$\overline{C_{FD}} = \frac{C_T - C_P}{n}$$

53 where

54  $\overline{C_{FD}}$  is the average capacitance of the  
55 photodiode,  
56  $C_T$  is the total capacitance,  
57  $C_P$  is the parasitic capacitance, and  
58  $n$  is a number of active pixel sensors of the  
59 group of active pixel sensors.

Please cancel Claims 1-22 and 24-29.